DESIGN OF MODERN ABATTOIRS

BY

L. L. EDLUND

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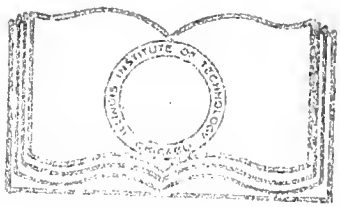

STRUCTURAL CONSIDERATIONS
IN THE
DESIGN OF MODERN ABATTOIRS AND COLD STORAGE WAREHOUSES

A THESIS

PRESENTED BY

LAWRENCE L. EDLUND

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APPROVED:

Professor of Civil Engineering

Dean of Engineering Studies

Dean of Cultural Studies

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INTRODUCTION

In spite of the fact that people have always had to eat and that there have been those whose business it has been to prepare animals for human food, the meat packing industry as we know it to-day is quite young when compared with some other branches of business. It is only a generation or so ago since the largest establishments had their beginning, and the industry with its present efficiency has grown rather slowly, step by step, from the very crude methods of thirty or forty years ago.

The buildings which have housed these meat slaughtering establishments have had a similar development. In the earlier days of the industry, comparatively little thought was given to the planning and designing of buildings, and those which were

built were not very different from what was used in other lines of business. They were not especially adapted to the needs of the meat packing business, and it has only been within the past fifteen or twenty years that men trained in engineering methods have been given to supervise the design and construction of such buildings.

In the days when the industry was developing, because of a genuine competition, improvements in methods, and new economies and processes were very closely held by the various companies. On this account, planning for extensions and additions to plants - and this was mostly what packinghouse construction consisted of at that time - was largely in the hands of plant superintendents and men not especially trained along structural or architectural lines. It is quite natural, therefore, that these phases

of the problem should not have received the attention which they deserve. There are a great many buildings still in use which bear witness to this fact.

If there is any industry which requires that very special consideration of its methods be given at the time new buildings are to be designed, it is certainly this one. It has many characteristics and requirements of its own and practically all of these have direct bearing upon the structural design as well as upon the general layout and arrangement. In one instance it may be desired to add a building for the slaughtering of cattle; in another a new cold storage building is needed. It is impossible to design either of these so as to serve their purpose properly without a very intimate knowledge of the work that is to be carried on in them. In recent years

there has been a marked increase in the number of small, so-called, independent packing concerns. In designing plants of this kind it has been necessary to study every phase of this business with a view to securing the most economical layout of the various buildings and arrangement of the departments in each.

The packing industry has recently developed quite a spirit of co-operation so that now practically all improvements in method are common property and are no sooner adopted in one plant than they are known to all others. Along with these changes, there have come into existence engineering and architectural organizations specializing in the design of buildings suited to this industry. These people have studied the needs of the business and by bringing to it their engineering skill have brought about many

marked improvements. The result has been that the new meat packing plants recently constructed compare with the finest of other industrial buildings in structural, architectural and mechanical detail.

FORMER METHODS OF CONSTRUCTION

Although it is the purpose in this thesis to deal primarily with structural problems in modern plants, it may not be amiss to consider very briefly the types of buildings formerly used in this industry. For the most part the old packing plants which are still in use are of the class which the Chicago Building Code calls "Ordinary Construction." The buildings consist of brick bearing walls with wooden floors, joists and posts. Usually no effort has been made to employ heavy structural timbers to advantage, but the members are just the ordinary sizes used in general building work. In most cases the thicknesses of bearing walls seem to be ample and to agree with modern practice, but the foundations seldom have been properly designed,

and cases have been found, when it was desired to add to old buildings of this kind, that according to all methods of analysis and design they should have failed long ago.

In the packing house business the floors in practically all departments are very wet and it is the custom in the older buildings to put down a wearing surface of about an inch and a half of asphalt on top of the wooden floor. This has aided in keeping the floors more sanitary and has in a measure prevented rotting of the wood underneath.

Many of the older packing house buildings are very conspicuous for their lack of natural lighting. Where windows have been provided, they are usually small and quite inadequate, and in most of the work rooms artificial illumination is necessary all day long.

Another very noticeable defect is the lack of adequate, safe stair facilities. The older plants have grown, building by building, and a point has been reached in many of them where it is practically impossible to find the way out, even when time is no object. The danger of such a condition in a time of fire or accident is obvious.

The older plants are generally very deficient in proper sanitary toilet and locker facilities for the employees. Because of the nature of their employment, a very large majority of the plant help must make an entire change of clothing both morning and evening, and many are obliged to take shower baths. Modern sanitary fixtures are not generally found.

What has been said conserning packing

houses applies equally to cold storage buildings, whether connected with a packing plant or operated as commercial warehouses. One very necessary requirement in a cold storage building is that it be kept sweet and clean. How this was accomplished in some of the older type of buildings is a mystery. No doubt, the advent of reinforced concrete buildings for this business has greatly assisted in developing it into the large industry which it now is.

A good many materials and combinations of materials were used to insulate these buildings against the warmth outside. Among these may be mentioned sawdust, building paper, dressed and matched lumber, hair felt, mineral wool and hollow tile. In some cases, three or four of these were used in combination, and sometimes only sawdust was used, held in place by wood partitions. Some of these arrangements were very hard to keep

dry and sanitary, and in all cases the advent of the use of corkboard for this purpose has been a great improvement. It not only provides a better and neater insulating material, but simplifies the structural problem as well.

PRESENT METHODS OF CONSTRUCTION

To-day the very large majority of new slaughter houses and cold storages are being built of reinforced concrete. The advantages in the use of this material are fully as great in this industry as in others, and in some respects, perhaps a good deal more so. In most of the departments of a packing house, the floors are always wet, and the ease with which they may be pitched to drains when concrete is used is a great advantage. Then too, concrete floors do not absorb moisture and get unsanitary in the manner that wood does. If properly treated with a good hardner they will withstand considerable hard use without deterioration. In places where a great deal of heavy trucking is to be done, it is customery to lay a paving of vitrified brick one and a quarter inches thick over the reinforced concrete floor. Such a pavement, when well laid, is practic-

ally indestructible.

Packing houses contain a great deal of heavy machinery and it is an easy matter, with concrete, to provide proper framing to carry these heavy concentrated loads. In many cases these consist of large steel tanks which hang through the floor and are supported from the slab or from beams especially framed to take them. There is also a great deal of driven machinery which in a wooden building causes excessive vibration. Concrete construction does away with all vibration besides providing better means of support.

Of course, the advantages of permanence and improved fire risk are worth as much to the packing industry as elsewhere, and these have been added incentives to bring concrete construction into favor.

In the newer plants, a very noticeable departure is in the use of large steel sash which are generally employed throughout the manufacturing buildings, and all departments

are planned to get all possible daylight. In addition to this, many added comforts for the employees have been incorporated in the large and well ventilated toilet and locker rooms now being provided.

The changes in type of construction and methods of operation which are now apparent have come about very largely because it has been found to be good business policy. Reinforced concrete has won the first place in modern factory construction and has many added advantages when used in the packing house business. Then too, the trend of modern time has been along the lines of providing better working conditions, more light, better ventilation (perhaps more needed here than elsewhere) greater safety, etc. Reinforced concrete construction is an aid in the accomplishment of these results.

All slaughtering done for interstate business must be done under the inspection

of the United States government. This inspection is a part of the work of the Bureau of Animal Industry of the Department of Agriculture. This department has brought a great deal of pressure to bear that has helped to improve conditions which formerly existed in packing houses. In fact, the entire movement had its beginning when the government took active steps to clean up the stock yards in Chicago some years ago, and the advance that is to-day noted dates back to this effort. They are still at it and their rules and regulations are constantly undergoing change, and not a few of their demands affect the structure itself and the arrangement of departments.

The influences which have brought about a change in the buildings used for cold storage have not been so many. Here it has been largely a matter of following the trend of the times along building lines. The general use of corkboard for insulation has, no doubt,

helped some to bring this change about. It was not formerly the custom to build very high, four or five stories were customary, but to-day there are a number of these buildings which are ten stories and more high. When a cold storage building is an adjunct to a packing house, it is seldom made higher than five stories even now, unless it is to be used entirely for the storage of frozen products. In commercial cold storages, however, where frozen meats, fruits, vegetables, etc. are held for a market, there is no reason why the buildings should not be made as high as is structurally economical.

This increase in the height of cold storage buildings involves often times some unusual designs. The live loads in these buildings are two hundred pounds and more per square foot, and as it is desirable that the columns in the lower stories shall not occupy too much of the available floor

space, concrete encased steel columns are sometimes resorted to.

Improved methods of construction, insulation and refrigeration make of the modern cold storage plant a very clean, wholesome and sanitary place for the storage of fresh foods.

THE BUILDING REQUIREMENTS OF A PACKING PLANT

A packing plant as we know it to-day, is an establishment for the slaughtering of live stock and the manufacture of all the by-products incident thereto. In the majority of cases it is a self-contained plant in that it has its own power plant for the production of steam, electricity and refrigeration, its own independent source of water supply, and in many cases its own stock yards for the receiving and sheltering of stock. Therefore, in addition to the slaughtering and cold storage buildings are others for the housing of the by-product industries as well as the other adjuncts to a complete plant.

Among the products sold by packing plants and directly derived from the slaughtering of live stock may be mentioned the following:

Fresh Dressed Beef
" " Pork
" " Veal
" " Mutton

Fresh Dressed Poultry
Beef and Hog Offal
Sausage
Smoked Meats
Cooked Meats
Cured Meats
Dry Salt Meats
Lard of Several Grades
Oleomargarine
Grease
Tallow
Soap
Neatsfoot Oil
Bone Products
Poultry Feed
Fertilizer
Hides and Pelts
Curled Hair

The larger plants produce all of these and more besides. Others may specialize in either beef or pork slaughtering, and some do both on a small or moderately large scale. Existing plants may be found in a great variety of capacities. Only the largest plants go into the manufacture of all the by-products, the smaller ones simply carry the process to a certain point and then sell the unfinished product to others who carry it to completion and sell the finished article.

This applies particularly to oleomargarine, hides, pelts, bone products, fertilizers, poultry feeds, soap, etc.

The size of a plant is usually given on the basis of its killing capacity, and in the laying out of a new plant, the space to be devoted to the different departments is based on this same killing capacity. This in the case of cattle may be almost anything from eight per hour, upwards, and in the case of hogs it may vary from say fifty to five or six hundred per hour with a single set of equipment. In providing space for the various departments, it is estimated that this hourly capacity will be kept up throughout a ten hour day. Variations from this are, however oftentimes made in individual cases.

Besides being dependent upon the killing capacity, the extent of a proposed plant will also vary with the extent to which the owner desires to go into the manufacture of by-products.

In general, however, it may be said that any packing plant of whatever size will have the following departments:

General Office	Shipping Dept.
Slaughtering Dept.	Freezers
Chill Rooms	Miscell. Coolers
Fresh Meat Coolers	Tank House
Cutting Dept.	Oleo Stock Dept.
Offal Chill Room	Grease Dept.
Gut Separating Dept.	Bone Dept.
Casing Dept.	Hog Hair Dept.
Dry Salt Curing	Hide Cellar
Sweet Pickle Curing	Tankage Pressing
Sausage Dept.	Blood Cooking
Sausage Coolers	Fertilizer
Smoke House	Power House
Lard Refinery	
Lard Cooler	

In laying out new plants, it is now the aim not only to arrange these departments so as to reduce labor by gravitating from one to the other, but also to combine in separate buildings those of a similar nature, especially the departments which are the most unpleasant so that means may be provided to confine and condense obnoxious vapors etc. where they originate and not contaminate the entire plant.

For these reasons, the departments are generally grouped, in a medium sized plant, about as follows. The departments are given in the order of the floor on which they are located, starting in the basements going up.

ABATTOIR BUILDING

Hide Cellar
Grease, Tallow, P.S.Lard and Oleo Stock Tiercing
Grease and Lard Drawing off, and Oleo Melting
Tank Charging, Offal, Casing Dept.
Slaughtering

COLD STORAGE BUILDING

Sweet Pickle Curing
Dry Salt Curing, Lard and City Trade Coolers
Freezers and Storage Coolers
Sausage and Sausage Meat Coolers and Pork Cutting Dept.
Hog, Beef and Offal Chill Rooms

PACKING BUILDING

Washing and Stringing Cured Meats and Smoke House Firing
Shipping Dept., Smoke House
Lard Refinery, Smoke House
Lard Refinery, Sausage Dept., and Smoke House
Miscellaneous Storage

FERTILIZER BUILDING

Fertilizer Drying and Disintegrating
Fertilizer Storage
Fertilizer Screening, Tankage Press
Tankage Skimming, Blood Cooking and Tank Water Storage
Bone Department

Of course, this arrangement is only representative, and can be deviated from to almost any extent desired. Besides the departments mentioned, a good deal of space must also be given to toilet, locker and lunch rooms for employees, for miscellaneous dry storage and other purposes.

The classification which the Bureau of Animal Industry gives to the various departments is of considerable importance in this connection, and has much to do with their location in certain of the buildings. In the course of the government's inspection of the slaughtering, certain animals or portions thereof are condemned for human food because of disease. These must be set apart from the good and cannot be used in the manufacture

of any food product. These therefore are rendered for the grease which they contain, as are also certain parts of the viscera of animals passed for food. Without going too much into detail, it may be said that separate equipment must be provided for rendering, drawing-off, and tiercing of the grease and lard received from the rendering of the bad and good respectively, and direct communication from one of these departments to the other is not permitted. In the same way, the government classes the casing cleaning, hide storage, bone and fertilizer departments as inedible.

It is necessary in arranging the different buildings to see that the cold storage and packing buildings are provided with good loading dock facilities, both for railroad and wagon shipping and receiving. The abattoir building also requires a railroad platform for the shipping of tierced grease,

tallow, etc., and for the fertilizer building similar facilities are necessary for the shipment of its products. Provision must also be made for unloading coal to the boiler room.

Each building requires its own elevators and stairways, the number depending on the size and arrangement of the plant. In some cases, separate elevators must be provided for the carrying of inedible products such as fertilizer, hides, grease, etc. and these cannot be used for foods.

The problem of drainage and sewers is a very important one to all packing plants, and becomes more so if the plant is located in a city where its wastes if discharged directly into the city sewers constitute a nuisance. It is customary in all plants to use some form of separating basins in order to catch the grease which gets on the floors and is carried away in washing up. Practice differs

in this matter in different plants, some preferring to use one large basin through which all sewerage passes, and others employ a number of basins located in different parts of the plant. Neither method is entirely effective in removing all the grease from the outgoing sewage, although the adherants of each method think their's is the best. Of course, this desire to get out all of the grease is due to its commercial value and not because of any great desire to keep it out of the city sewerage system. Municipalities do, however, insist in many cases that other solid matter which is carried in suspension be removed. The most effective method of accomplishing this result is still subject to experimentation. In small plants, the use of a large separating basin so constructed as to greatly reduce the velocity of flow and by other means cause the throwing down of material carried in suspension will suffice. It must, however,

be cleaned out very frequently if it is to function properly. In large plants as at the Chicago stock yards, the activated sludge method is being experimented with and gives promise of success.

Within the plant itself, it is necessary that the floors be pitched to a generous number of heavy floor drains, and that the connecting lines of these drains be made of rather large size to prevent clogging up. Cleanouts must be provided at least every fifty or sixty feet because although the drains be provided with grating and strainer, plant employees will remove these and sweep all manner of material into the drain and cause the lines to become stopped.

For a plant of medium size, it is perhaps best to provide separate grease skimming basins in each building. In the abattoir two should be put in, and all should be skimmed daily. In addition to these grease basins, the main sewer line should discharge

into a large sediment trap before passing out of the plant.

It is desirable that all the manufacturing departments be provided with the best light and ventilation possible. This can best be accomplished by the use of ventilated steel sash. The operations carried on in the slaughtering and gut departments are of a nature that produce a great deal of steam. This gives rise to a very bad condition, especially in the winter, and to relieve this it has been found advantageous to install an indirect blower system of heating for these departments, providing fresh warm air at the rate of a change every five to ten minutes.

The special provision which must be made for rendering tanks, skimming vats, lard kettles, etc. will be considered later in another section. Their size and location have a good deal to do with the structural

design and call for special consideration.

In the older plants, cold storage rooms were sometimes built in buildings mainly used for manufacturing purposes. When this is done, it becomes difficult properly to insulate these isolated ice boxes. It is obvious that to secure the best efficiency, all cold storage for a packing plant should be combined in a building devoted to that only, completely insulated from top to bottom and located conveniently to the other buildings of the plant to facilitate the necessary plant operations.

It is very desirable that the floor levels in the cold storage building be made to coincide with those of the other buildings adjacent so as to facilitate trucking back and forth. This is very important as a majority of all products are carried in trucks pushed by hand, and even small inclines are difficult to ascend with a load.

Furthermore, if the floor and inclines are of concrete it will be only a short time before they are deeply cut into by the iron wheels of the trucks. In the most important passages, it is customary to use a paving of vitrified split brick over the concrete, but this construction is rather expensive and cannot be used everywhere.

Because of the subdivision of the stories in a cold storage building, it sometimes is necessary to place corkboard insulation on the floor. In cases where this insulation only covers a portion of a certain floor, in order to avoid bad inclines, that part of the slab is depressed below the rest so that when the concrete wearing surface is laid over the cork, the entire floor will be at the same level.

Generally speaking, it is preferable that no windows whatever be used in the cold storage building and that all illumination

be by electric light. These rooms are practically all for storage, and general aisle illumination is all that is required. Sometimes the insulation is so arranged that the elevator and stair shafts are outside of the cold sections and are considered warm. In cases of this kind, windows can be employed to light these shafts.

The pork cutting department is usually located in the cold storage building. This department employes a large number of men who are engaged in cutting up chilled hogs into the various trade cuts such as hams, bellies, shoulders, loins, etc. Here it would be an advantage to have some natural light and this could be secured by using quadruple sash. If, however, this room is so located in the building that the use of windows would mar the architectural effect of the exterior, they can be omitted without much harm, as in any case they would

have to be supplemented with electric light at all work tables.

This outlines in a rather hurried fashion some of the special building requirements of a medium sized packing plant. Some of the smaller, but quite important details will be discussed later on in connection with the general problem of the design of a plant of this type.

THE BUILDING REQUIREMENTS OF COMMERCIAL COLD STORAGE WAREHOUSES

Where a cold storage building is a separate commercial warehouse, not connected with a packing house, and devoted to the storage of a large variety of foods, there are a number of features which enter into its design which are not, perhaps, met with in packing plant warehouses. Among the goods which are stored in these houses may be mentioned frozen meats, frozen poultry, frozen fish, butter, eggs, apples, peanuts, fruits of all kinds, etc. The meats, if they consist of halves of hogs or quarters of beef, are usually covered with burlap and are piled directly on the floor. Smaller cuts of meat are boxed, fish are either piled on the floor, or put in pans which are set on the pipe shelves provided in some fish freezers. Butter is usually in tubs, eggs in cases, apples in barrels, peanuts, potatoes, etc.

in sacks. In most cases it is customary to pile as high as can conveniently be reached from the floor.

The convenient height for piling together with the space required overhead for refrigerating coils and sprinkler headers enter into the determination of the story heights.

In the operation of these houses, it is customary to rent out rooms to commission firms and others owning perishable goods which they desire to hold. Therefore the sizes of rooms are varied to provide for the class of trade which is anticipated.

Of early importance in laying out such a plant is the location of the shipping and receiving docks. These will in turn affect the arrangement of elevators and stairs and will determine the location of corridors and subdivision of floors. Ample railroad track facilities are necessary, and a large dock for city delivery must also usually be pro-

vided.

The height to which the building shall be carried is of course for the owner to decide and will depend upon the value of the ground on which he will locate and upon the money which he wants to put into the enterprise. There is a limit, however, to the height to which it would be economical to go.

In a commercial warehouse of this kind, provision must be made for the engine room. When the house is a part of a packing plant, the refigerating machinery is usually located in a separate building, but in commercial warehouses of this kind, space must be provided in the basement for ammonia compressors, brine coolers, pumps, condensers, etc. If the plant is to be steam driven, a boiler room is also necessary, and this must be located with reference to getting coal in from the railroad serving the plant. If the compressors are to be synchronous-motor

driven, it will probably be necessary to have transformers located inside the building. In connection with the location of this equipment it is desirable to keep in mind where the risers serving the various floors are to be run in order that the piping may be made as simple and direct as possible.

It is well to provide occasional floor drains in all cooler rooms to facilitate washing the floors. These will have to be omitted from freezers, however, as it would be difficult if not impossible to keep the traps from freezing up.

The ideal method of insulating a building of this kind would be to build the interior structure and then surround it on all sides and over the roof with corkboard insulation which should nowhere be punctured with any conducting material. Outside of this cork insulation should then be built a self-supporting brick wall as a protection

and to secure the desired architectural effect. This is the ideal and it is quite closely approximated. It is, however, occasionally necessary to carry some structural members through this insulation, especially is this true where the stairwells and elevators are outside this cork envelope and are to be considered warm territory. In addition to this, the outer self-supporting wall must be tied to the inner concrete structure by means of steel anchors at each floor level on each bay line. Doors are also necessary, and these are made of the cold storage type which contains the same cork insulation as is in the wall in which they are hung.

The Chicago Building Department is not satisfied with the outer self-supporting wall construction above mentioned, but require a separate concrete structure consisting of columns and spandrel beams to support the wall. This outer framing is set about five inches clear of the inner and is anchored to

it at the time the concrete is poured.

It is usually found desirable to equip these warehouses with automatic sprinklers. The dry pipe system must be used in the storage rooms, but the stairwells may be equipped with the wet pipe system. Provision must therefore be made on the roof for a gravity tank, and room devoted in the engine room or thereabouts for the dry valves and an air compressor.

If the stairwells are to be heated, or if the building is to contain an office which will require heat in the winter, provision will need to be made for a small heating boiler, if there is no high pressure boiler for furnishing steam to engine-driven compressors. It would be well if this could in some way be located in a lean-to building, separate from the rest of the plant so that the stack could run up on the outside. If, however, the stack must be carried up inside

the building and it cannot be worked into one of the warm stair shafts, it will have to be specially designed and insulated both with flue lining inside and several layers of cork on the outside. This will constitute a rather mean problem and will be a very expensive stack for the purpose it serves.

Other more detailed structural points which are common to both commercial and packing house cold storages will be discussed later on in another section.

DESIGN OF A MODERN MEAT PACKING PLANT

- LAYOUT -

In order to illustrate the problems which must be solved in designing a modern reinforced concrete packing plant, we will consider one of medium size and follow through the layout of the various buildings and the factors controlling the structural design of each.

We will assume that it is desired to plan a plant that shall have a slaughtering capacity of three hundred hogs an hour and be equipped with double cattle beds. The plant is to be equipped to do a general packing house business including the making of sausage, smoked meats, kettle rendered and refined lard, oleo stock, dried tankage, dried blood, white and brown grease, and dried bones. The plant is to have a power house for the supply of steam for all manufacturing processes and to drive the ammonia compressors. It is stipulated that

the plant and equipment shall not cost in excess of one million dollars at present prices. It is further desired that the plant be laid out with a view to future extensions, particularly of the cold storage section.

The limitation of cost at once places a limit on the floor area which may be built. We will not be far out of the way if for purposes of a preliminary layout we assume a unit price, including machinery, of $6.00 per square foot of all buildings. On this basis we may build 166,600 square feet gross. This represents the total allowable floor area and to be on the side of safety, it will be well to keep somewhat within these limits.

Considering the size of the plant and the extent of the business, it seems necessary that it should consist of the following buildings: abattoir, cold storage,

packing building, fertilizer building and power house. As a starting basis it will be necessary to apportion the total floor area among the different buildings according to their needs and with this subdivision lay out each building in detail and arrange all equipment. While this is being done, we can make any minor variations from the areas figured that may be found necessary.

From other plants formerly designed, we know that the least we can get along with in the fertilizer building is three by four bays. This building must be at least three stories and basement. If we assume 16' 0" by 16' 0" bays, this gives us an area of 12,288 Sq. Ft. Some sketching of the killing floor in the abattoir shows us that we will require a building five by five bays each 18' 0" square. This building must be at least four stories and basement to accommodate the departments that should go into

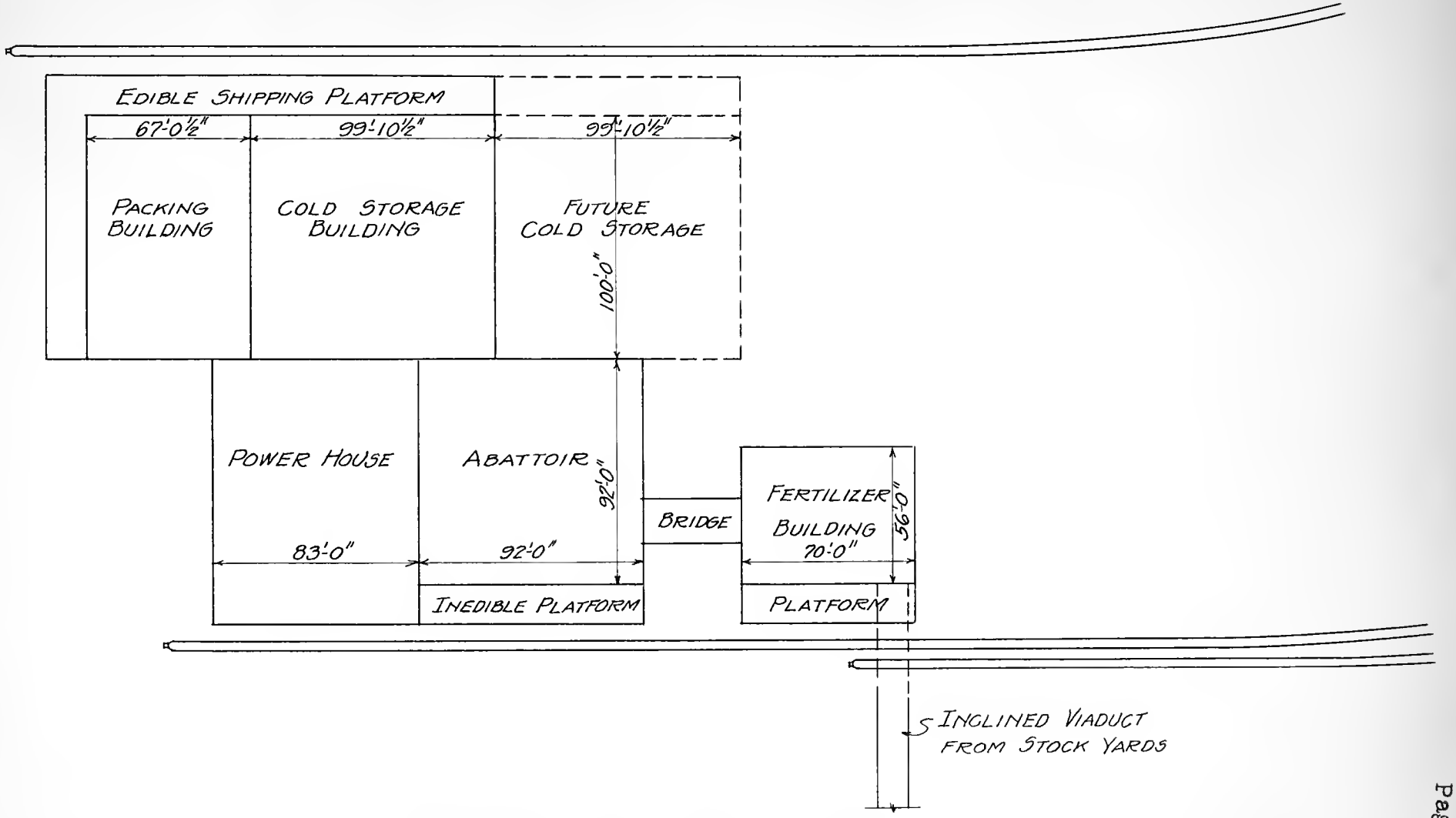
it. From this we get 32,400 Sq. Ft. The Packing Building is to contain the sausage department and lard refinery. These and the smoke houses make up the principal manufacturing departments in this building, and these will all come on one floor. A tentative sketch of this floor shows that we will require a building four by six bays, 16' 0" each way. This will add 30,720 Sq. Ft. There still remains the power house and the cold storage building. We will assume the former to be 80' 0" by 100' 0" or 8,000 Sq. Ft. The buildings so far mentioned aggregate 83,408 Sq. Ft. The fixed expenditure limits us to 166,600 Sq. Ft. This leaves a balance for the cold storage building of 83,192 Sq.Ft. The cold storage will be assumed as six bays wide and four stories and basement high. If we assume 16' 0" square bays, the permissible length becomes 173.3 feet. We will figure on a building considerably less than this in

order to be provided against unforeseen increases in cost over those figured on, and make this building six by six bays or 46,080 Sq. Ft. Having arrived at these approximate sizes of the different buildings we will give some study to securing the best possible grouping of them and then proceed to design each building separately.

In making a general arrangement plan the governing principal must be the procedure followed in the operation of plants of this kind. It is desirable as far as possible to reduce trucking distances and to chute products by gravity from one floor to the next instead of taking them on elevators. From these considerations, the departments range themselves quite easily and leave only a very few which may be located in any one of a number of places. Such an arrangement was given in the section on the building requirements of packing plants, p. 21, and this will in general be followed in this case.

The grouping of the buildings depends upon the same features as the occupancy of the different floors in each building. It is necessary that they be compact, that they have outside light and ventilation, and that they be arranged as far as possible in the line of the processes carried on. It is also desirable that the power house be so located as to make it convenient to get steam, hot and cold water, ammonia, and brine pipes to the respective buildings requiring them. It is also quite important to bear in mind the loading platform and the arrangement of switch track facilities.

Each of the above points requires considerable study and sketching before a decision can be reached. To go into the details of these matters would be burdensome and not exactly relevant to the subject of this thesis. Suffice it to say that an arrangement such as shown in Fig. 1, page 44a meets in a very satisfactory manner the points mentioned and



GENERAL ARRANGEMENT PLAN

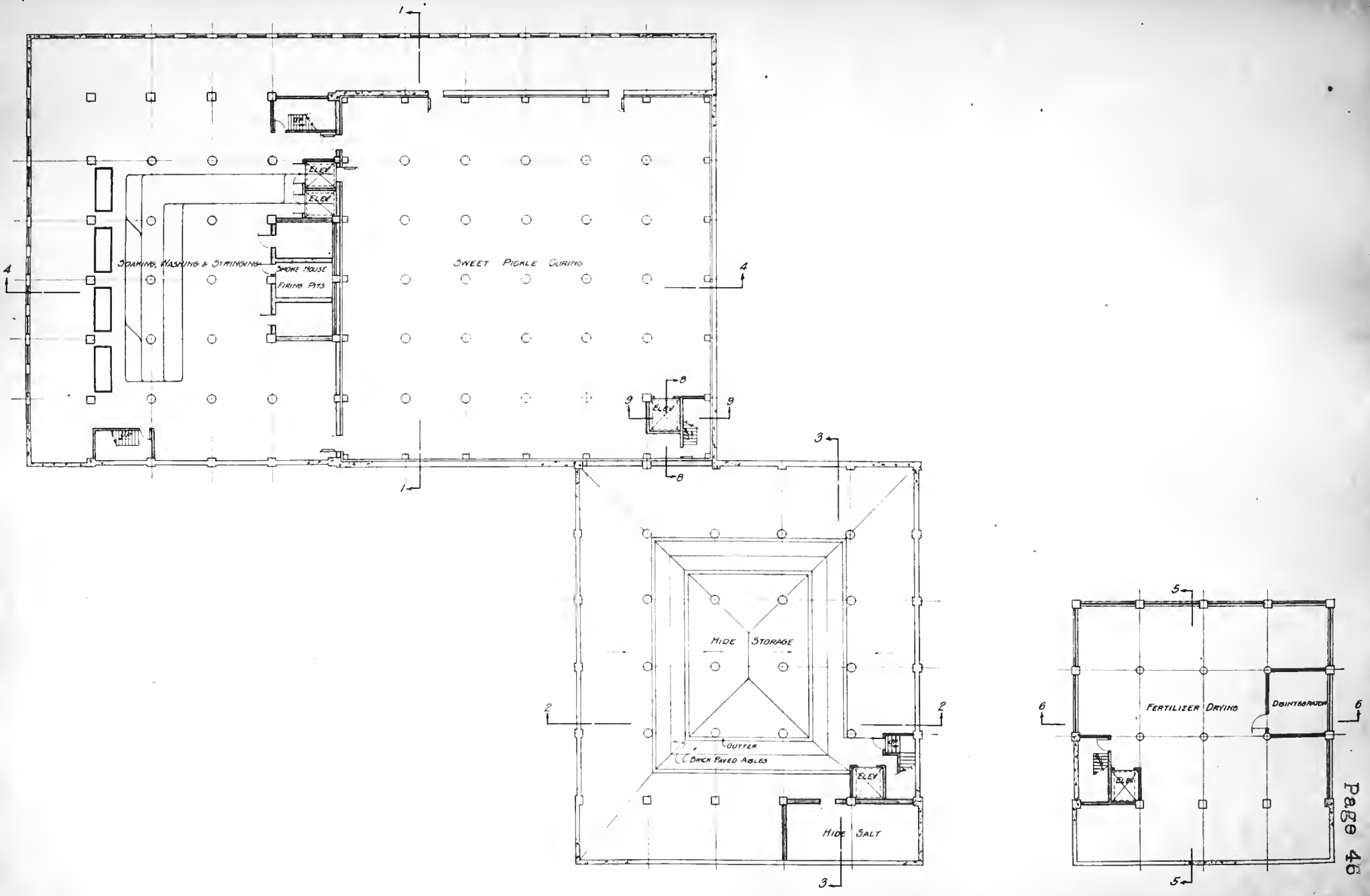
FIGURE 1

will be adopted as the layout of this plant.

Having decided upon the arrangement of the buildings, it is next necessary to make detailed floor plans of each, showing the location and arrangement of all equipment and designating the space to be devoted to each of the many departments. These plans will also show the general structural arrangement, give all general dimensions and serve as a basis for making calculations of the reinforced concrete structure.

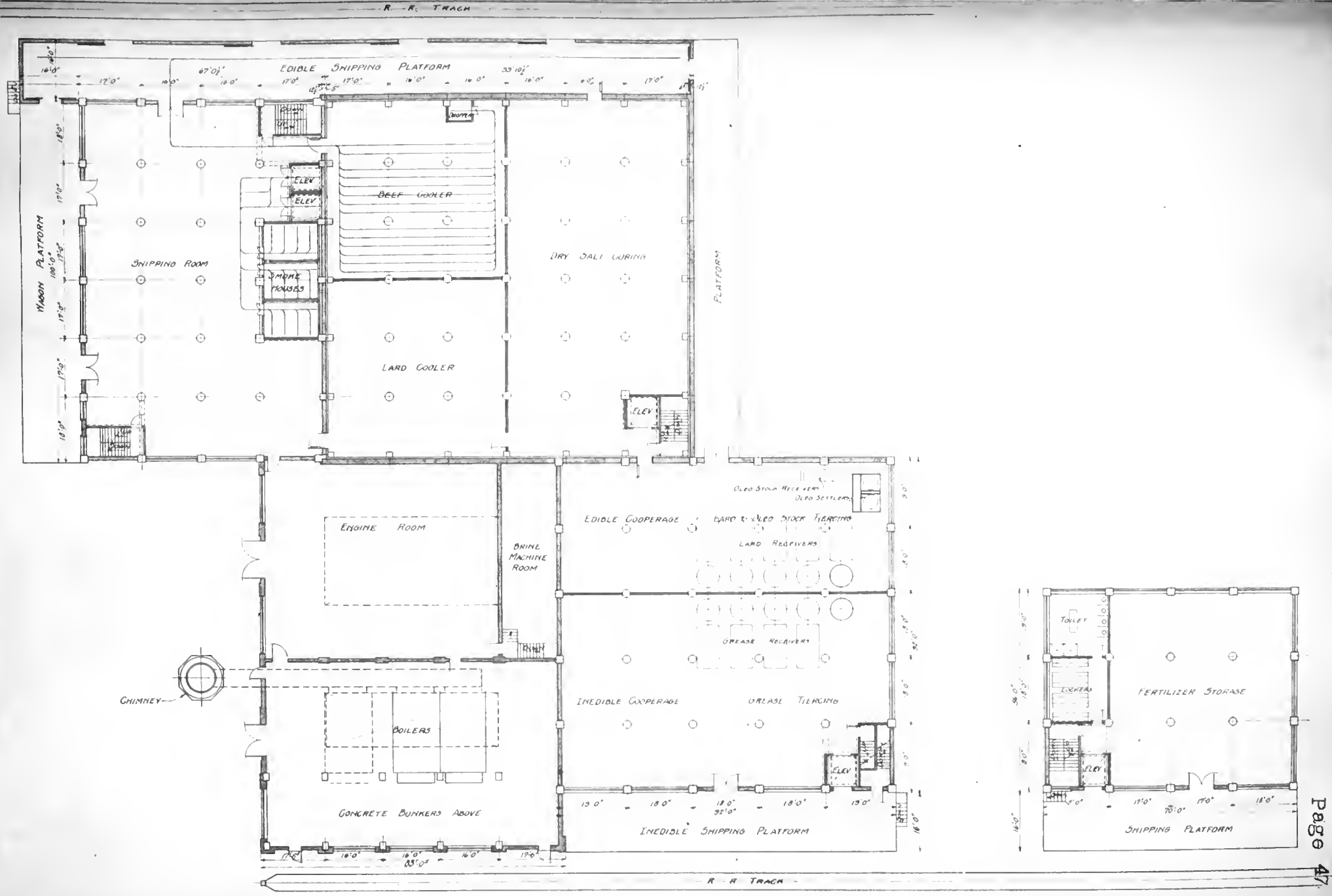
GENERAL REQUIREMENTS IN DESIGN

The general plans and sections of these buildings are shown on Plates 1 to 8 inclusive, pp, 47 to 53. These drawings have been made especially to illustrate this discussion, and considerable detailed information ordinarily a part of complete architectural plans of this kind have purposely been omitted in order to emphasize only those features which have a direct



COMPOSITE BASEMENT PLAN

PLATE 1

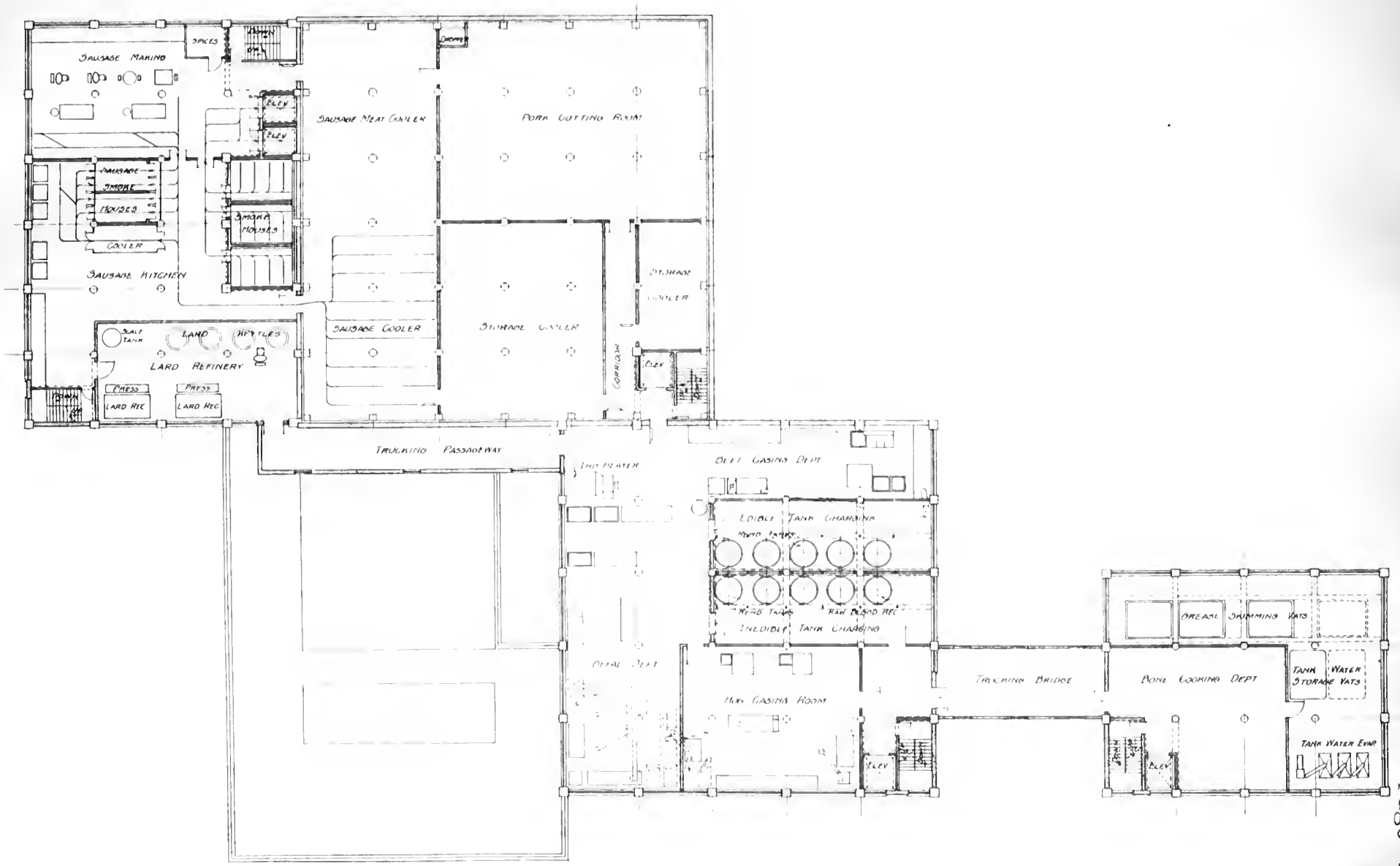


COMPOSITE FIRST FLOOR PLAN

PLATE 2

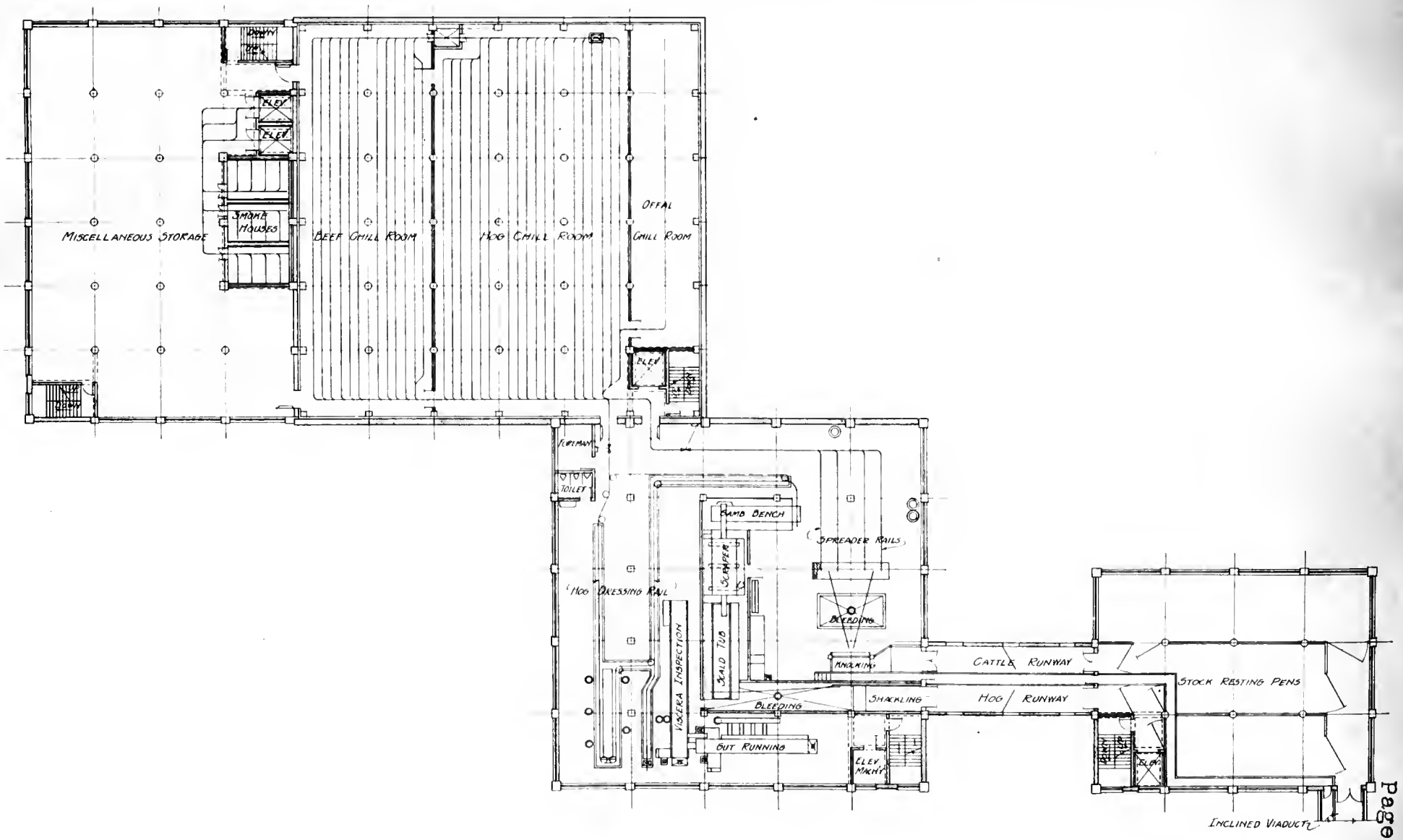
COMPOSITE SECOND FLOOR PLAN

PLATE 3

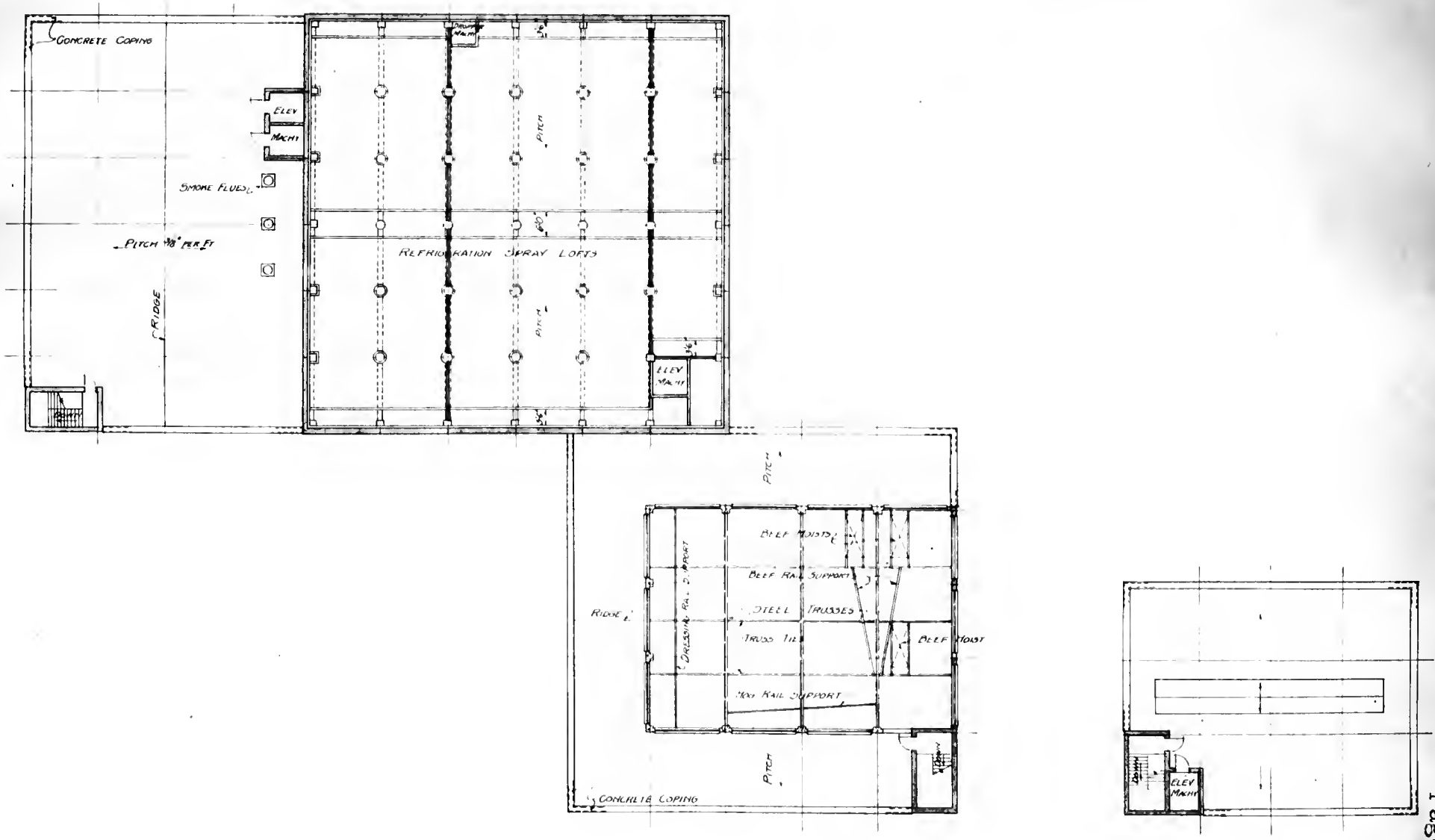


COMPOSITE THIRD FLOOR PLAN

PLATE 4

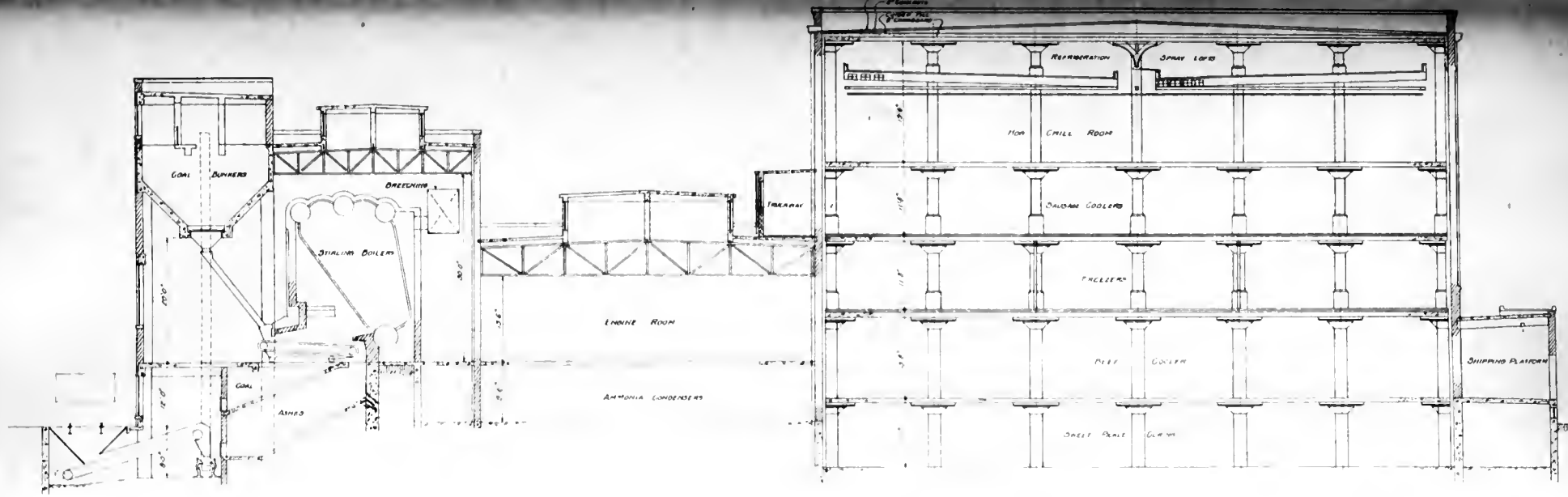


COMPOSITE FOURTH FLOOR PLAN
PLATE 5

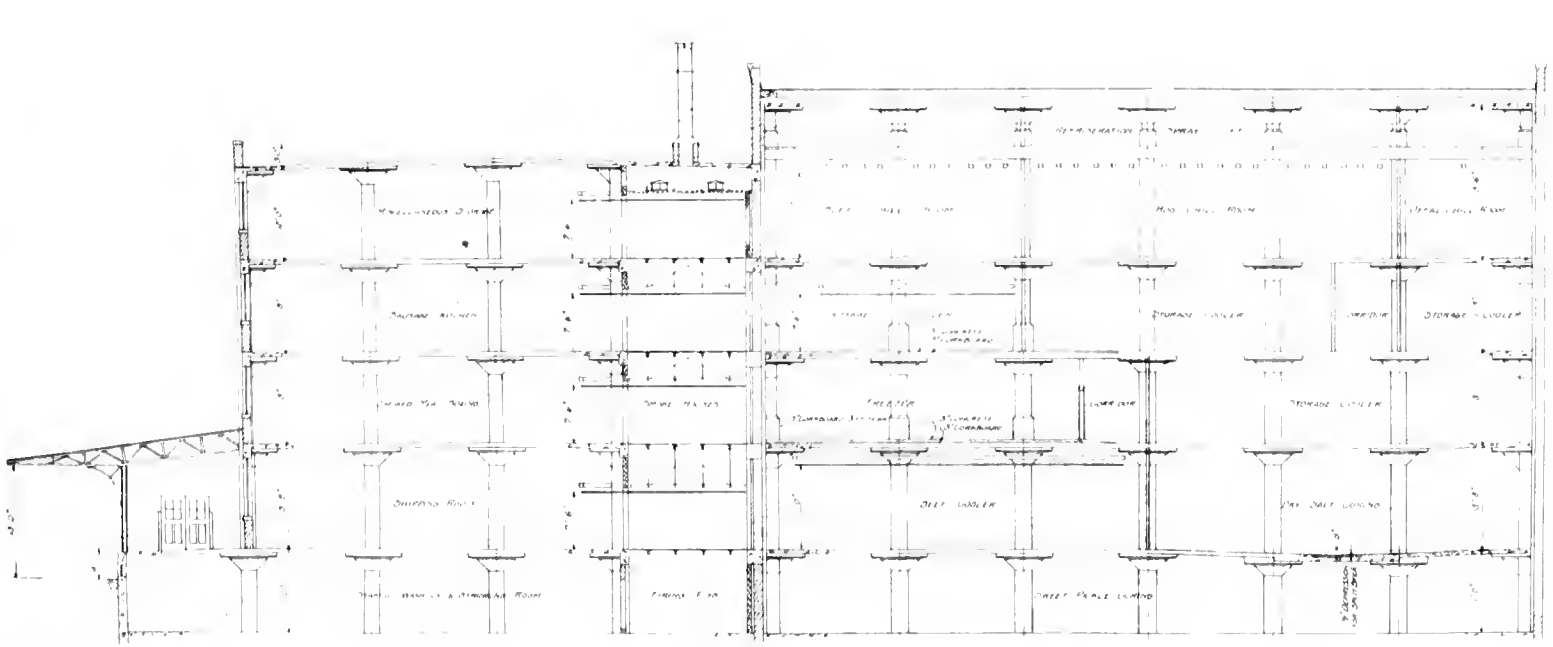


ROOF AND LOFT PLANS

PLATE 6



SECTION 1



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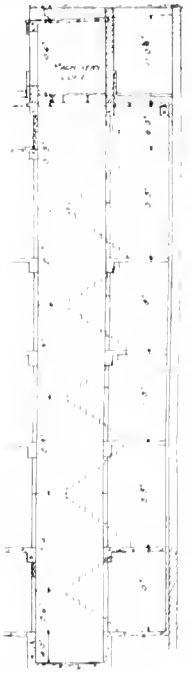
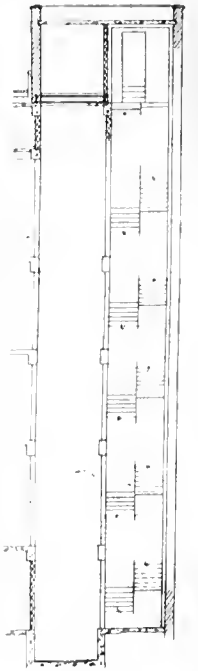
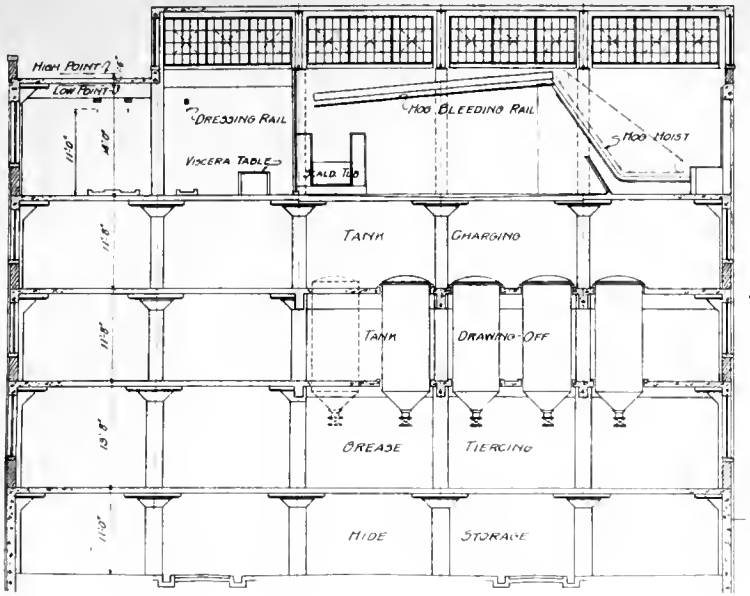


SECTION 8

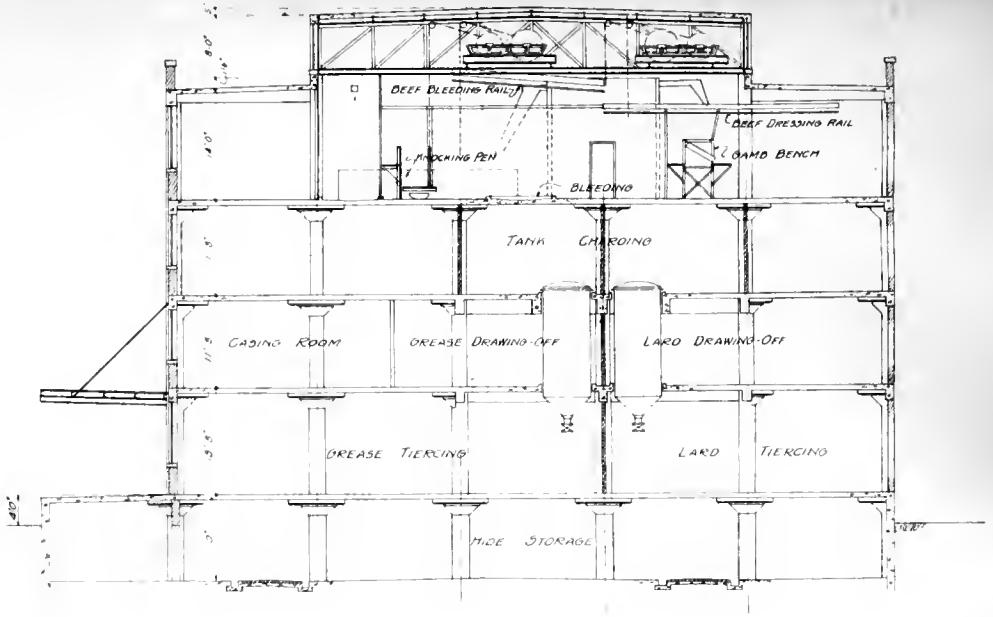


SECTION 9

PLATE 7



SECTION 2



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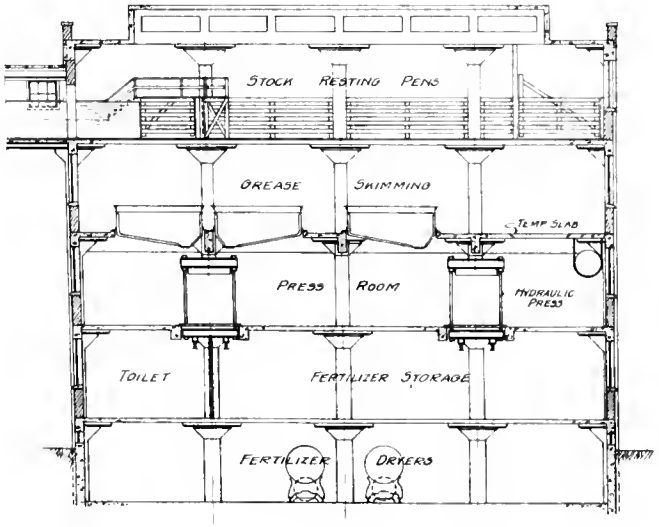
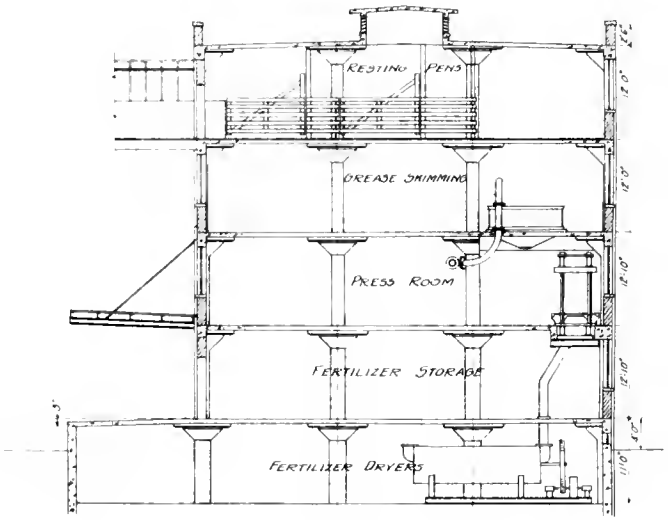


SECTION 6



SECTION 5

SECTIONS OF ABATTOIR AND FERTILIZER BUILDINGS
PLATE 8

bearing upon the problem of structural design.

Up to this point, nothing has been said concerning the type of concrete construction to be employed. It has been found that for the purpose of these buildings, nothing is quite so well adapted as the flat slab design. The elimination of beams and girders gives a far more economical structure because of a considerable reduction in the necessary height from floor to floor. Furthermore, it is much easier to run pipe lines and support line shafting, both of which are very important factors in a plant of this kind. The same advantages apply to the cold storage building with the further factor of the added ease of placing corkboard insulation on a flat ceiling where this is necessary or desirable. For the reasons mentioned, flat slab design will be used throughout the plant except in those places where special beam framing is necessary around tanks which

hang through the floor, and the framing around elevator and stair shafts.

It has been found from experience with the requirements of these plants that a story height of 11' 8" is sufficient and most economical for all buildings. The only exceptions are those floors which contain hanging tracks for beef, and the killing floor which contains several high machines. This story height will therefore be adopted throughout, with the above exceptions. These will be brought out again later in considering the departments in which they occur.

In figuring the sizes of the various buildings, certain dimensions center to center of columns were assumed; sixteen feet in the case of the packing and cold storage buildings and eighteen feet in the abattoir. In a building like the cold storage which contains no large equipment

affecting the size of the bays, these can be determined strictly on the basis of the most economical design. Practically throughout this building, the floor loads to be designed for are two hundred pounds per square foot. From estimates of costs of designs of varying spans and loads, it has been found that for this live load, a sixteen foot bay is the most economical and that as the live load increases, the size of the economical bay also increases. For this reason, where no other factors govern, we will use sixteen foot bays.

Another feature which must be considered now is the selection of sash. With concrete construction, it would hardly be fitting to use other than steel sash. By consulting the standards of the manufacturers, we find that they make units which require clear openings of fourteen, fifteen and sixteen feet. As we are to employ bay dimensions

of sixteen, seventeen and eighteen feet, we find that if we make the exterior columns of the buildings two feet wide throughout their height, we can use these standard steel sash units. We know from a rough approximation of the exterior column loads that 24" will be more than ample and that we are quite safe in specifying that in the manufacturing buildings all exterior columns be designed with the exposed faces 24" wide. We intend that these columns shall be exposed and that spandrel walls shall be employed. For the sake of uniformity of appearance, we will also specify that all spandrel wall beams shall be made 22" deep.

The structural design is to include a foundation plan as this has not been furnished with the architectural drawings. Approximate foundations and footings might have been shown on the cross-sections, but these would have added little information and

would be subject to change after the correct size and shape had been determined. The wall foundations may be of plain concrete but column footings shall be reinforced. Wherever possible, it is desired that the tops of footings shall stop six inches below the finished basement floor line. The soil at the site of the plant consists of a sandy loam of much greater depth than any footing is likely to go and the bearing used in design shall not exceed three thousand pounds per square foot. In designing columns and footings, the provisions of the Chicago Building Code shall be followed as to the percentage reduction in live loads allowed in the various stories. To secure as nearly as possible a uniform bearing (and consequent uniform settlement) on all foundations, these shall be designed as follows. The live loads on foundations shall be assumed to be the same as for the footings of columns. The

areas of the bases of the foundations shall be proportioned for the dead load only. The foundation which receives the largest ratio of live to dead load shall be selected and proportioned for the combined dead and live loads. The dead load on this foundation shall be divided by the area thus formed and this reduced pressure per square foot shall be the permissible working pressure to be used for the dead load on all foundations.

Reference to the cross-sections will show that all basement walls are to be of concrete up to the first floor level except in the cold storage building where they are to stop off at a point six inches above grade. All walls and partitions which are shown shaded on the plans are of either 12-1/2" brick or 4" tile plastered. On the second floor of the cold storage building, the unshaded partitions will be of 4" corkboard, plastered both sides. All spandrel walls

will be 12-1/2" brick except those where no windows occur. These will be made 8" brick.

Attention is called to the framing which is shown around all stair and elevator shafts. This may be deviated from if found necessary, but should be followed if possible. All stairways shall be figured for a live load of 100 lbs. per square foot.

In the basements of all buildings advantage has been taken in extending the floor out under the shipping platforms. This gives considerably more storage space at a small cost, as the platform would be reinforced concrete in any case.

With the exception of the top floor in the abattoir, the floor drains have not been shown on these plans. They will, however, affect the structural design somewhat. Drains will be used on all floors of all buildings (except above freezers) and the number and location will depend upon the occupancy. For the most part, there will

be one for every two bays, and in the worst condition, one per bay, located in the center. In the latter case the ridges will be on the bay lines and a drop of two inches is desired from there to the drain. This is to be secured by lowering the forms for the entire floor one inch and then making the slab an inch deeper than called for at the ridges and an inch shallower at the drains.

In all matters not covered elsewhere, the Chicago Building Code is to be followed. For reinforced concrete use values of f_s = 18000 lbs. per square inch and f_c = 650 lbs.

These general features having been decided upon, we can now take up each building separately and outline the live and concentrated loads to be designed for as well as consider any other special features which must be taken care of in designing the structure.

ABATTOIR

In order to provide for high rails and machinery as well as to give better lighting and ventilation, the killing floor will be provided with a monitor three by four bays in area. This is to be supported by three steel trusses spanning the shorter distance. Attention is called to the special loads which will be carried on beams framing into the lower chord of these trusses. The live loads to be considered are four thousand pounds each for the three beef hoists and a uniformly distributed load of four hundred pounds per lineal foot of the several rail supports. This figure includes a proper allowance for impact to which all of these will be subjected. The high roof should be figured for a forty pound live load.

The low roof over the killing floor shall be designed for a live load of one hundred and fifty pounds per square foot

which includes the load from dressing rails etc. Throughout all other floors, the live load to be figured will be two hundred pounds per square foot. Reduction to one hundred pounds can be made in toilet and locker rooms wherever they occur. The special concentrated loads which will exceed this average will be mentioned later as we consider the different stories going from the top down.

Only two other concentrated loads on the killing floor require special attention. These are the hog scraper and the scalding tub. The scraper rests on piers 7' 0" centers. These are shown on the plan. The center one gets 12,500# and the end ones 11,500# each. Figure the scalding tub at three hundred pounds per square foot. The various openings for chutes may be neglected. In the worst case they will not exceed 24" and the slab steel can be bent around them.

They have been purposely located with a view to missing the depressed heads of columns.

The blood drains shown will have concrete curbs all around them and a steep pitch can be secured by adding to the slab thickness around the sides. Otherwise pitch to drains will be secured as previously mentioned.

The entire killing floor will be paved with split vitrified brick laid in cement mortar. This construction requires 1-1/2" and will need be added to the dead load in computing the slab.

The elevator shown does not serve this floor, but the machinery will be located at or near this level. This will be of the overhead traction type of 3000 lbs. capacity.

Attention is called to the stock runway entering the building on the top floor. This viaduct is of steel construction with tile walls. The trucking bridge in the story below is hung from the trusses carrying the

upper floor and therefor the entire reaction comes on the two columns shown. Figure the roof at 40 lbs. per square foot and the two floors at 100 lbs. per square foot each.

The principal concentrated load in the third story is that due to the rendering tanks, the oleo kettle and the indirect heating apparatus. The two former hang through the slab. The rendering tanks are 6' 0" in diameter and require 6' 3" clear openings. These weigh 30,000 lbs. each plus 50% impact. They will be supported from specially designed steel framing which in turn will be bolted to the concrete beams surrounding the tanks. The concrete framing is to be designed as indicated by the dotted lines. The tank loads will come onto these beams at the points indicated by the heavy black dots. The proportion coming at each point is readily calculated. The oleo melter is 5' 1" in diameter and weighs 4000 lbs. loaded. It is provided

with four cast iron lugs on the sides and rests directly on the floor. The opening required is 5' 3" in diameter. The weight of the heating fan can be figured at 1000 lbs. and that of the heater coils at 5000 lbs.

None of the weight of the rendering tanks comes on the second floor. However, some framing will be required to carry the slab around these openings. The lard and grease receivers shown require floor openings of 6' 3" x 8' 3". The receivers are of steel plate with an angle all around on which they are supported on the floor. Beams will be required on all four sides. These tanks weigh 12,500 lbs. each when loaded.
The lard and grease settlers shown in the first story are supported about 3' 6" above the floor on timber supports. These tanks also weigh 12,500 lbs.

FERTILIZER BUILDING

The upper story of the fertilizer building will be used as a resting pen for live

stock. 100 lbs. per square foot should be figured for this floor. The roof can all be figured at 40 lbs. The elevator will be the same type as the others, but of 2500 lbs capacity.

The other reaction from the bridge to the abattoir will be taken by the columns of the third story. The inclined stock viaduct is supported from the spandrel beam at the fourth floor level. The last bent of this viaduct is fifteen feet from the face of this building. The viaduct itself is of heavy timber construction for a 100 lb. live load. It is covered by a light wooden roof.

The skimming vats in the third story hang through the slab. The required framing is shown dotted on the floor plan. These tanks require floor openings 8' 9" x 11' 3". The tanks are supported by angles around the outside, riveted to the tank sides and resting on the floor. They weigh 24,000 lbs.

each when full. The tank water vats stand directly on the floor. These weigh 32,000 lbs. The tank water evaporator also stands on the floor and weighs 30,000 lbs.

On the second floor, the hydraulic press is the only heavy equipment. It weighs 22,500 lbs. and is supported by steel framing bolted to the beams as shown on Plate 8.

The heater shown on the first floor plan is identical with the one in the abattoir building. The live loads to be figured in this building are 200 lbs. for the second and third floors and 300 lbs. per square foot for the first floor.

POWER HOUSE

The power house is to be of brick and steel with reinforced concrete roof and coal bunkers. There is to be a basement under the engine room for the housing of condensers, pumps, etc. The arrangement of the equipment has not been made as yet, but this will not affect the general structural design. There

is to be a monitor over both the engine and boiler rooms. These trusses will be supported directly on the brick bearing walls, but special columns will be required for carrying the concrete bunkers above. The plan and sections give sufficient data to illustrate the arrangement desired.

PACKING BUILDING

The packing building is to be designed for 200 lb. live loads throughout except the roof which will be 40 lb. as before. The principal feature of this building is the smoke house. The construction of this is well shown in section on Plate 7. It is an open well from basement to roof with steel framing at each floor level. This carries a light grating just stiff enough to walk on, and also supports the rails in the story below. The load on these rails can be figured at 150 lbs. per lineal foot. The doors to the houses are of steel with steel

frames between the concrete columns. The dividing partitions are of four inch tile.

The sausage smoke house shown on the third floor plan requires a depression of 3' 0" in the floor slab to provide space for firing. The sides of this pit can form the beams supporting it and the loads coming on the floor is almost negligible, say 50 lbs. per square foot.

The elevators shown are of the overhead traction type of 3000 lbs. capacity. The machinery for these will be located in a penthouse and the steel beams supporting it will rest on the roof slab.

The lard kettles on the third floor hang through the slab. They require holes 4' 9" in diameter and are supported by means of four cast iron lugs resting on the floor. The weight of each kettle loaded is 11,000 lbs. The lard rolls on the second floor weigh 12,000 lbs. each and are supported by

cast iron frames at the ends.

The platform serving the packing and cold storage buildings is to be enclosed by a brick wall and have a light reinforced slab over it. This should be figured for a forty pound live load except the outer ten feet which will serve as an icing platform and should be figured at 75 lbs. per square foot.

COLD STORAGE BUILDING

In order to secure good insulation the structural floor system will be separated from the outside brick walls which will carry no load but their own weight. There are to be anchors tieing the outer walls to the inner concrete structure at each floor level on every bay line. The outer wall will be 12-1/2" except in the first story which will be made 17".

The outside insulation will consist of four inches of corkboard and the various

floor slabs are to be held back a distance of five inches from the inside line of the brick wall. The cork will be eight inches thick on the roof and will join the wall insulation all around. This construction is shown quite clearly on Plate 7. Between the cold stroage and the packing building, split columns will be employed so as to avoid puncturing the insulation.

The live loads to be designed for will be 200 lbs. per square foot on all floors and forty pounds on the roof.

The refrigeration in the chill rooms in the upper story will consist of the new brine spray system. This requires a pan such as shown in section on Plate 7 and in plan on Plate 6. It has been found best to design this using hollow tile and concrete joists. The girders are to run parallel to the tracks and the joists at right angles thereto. This arrangement facilitates supporting the track timbers which are carried

from this pan. 12" x 12" x 12" hollow tile should be used and the joists made 4" wide. The tracks are hung from 6" x 6" timbers and this arrangement of tile and joists permits these to be supported every 32" which is about right.

The beef dropper machinery will be supported on an extension of the spray loft slab. The load of this equipment is 1200 lbs. for the dropper and 3000 lbs. for the load.

The elevator machinery is to be housed at the roof level as shown in Section 9. It will be of the same style and capacity as those used in the packing building.

The following loads are to be designed for: 200 lbs. per square foot for all slabs including the spray loft, 40 lbs. per square foot for the roof, First story beef rails 300 lbs. per lineal foot, miscellaneous rails elsewhere 200 lbs. per lineal foot.

Floor and ceiling insulation is required to enclose the freezers on the second floor. This will consist of three inch corkboard with a wearing surface of three inches of concrete. The wearing surface will be reinforced with wire mesh. In order to provide level floors for trucking and avoid inclines we will depress the slab where this floor insulation occurs so that when finished the top surfaces will coincide. This requires a drop of six inches in the reinforced slab and must be provided for in the structural design.

CONCLUSION

Although the problems brought out in this discussion represent the ones of chief importance in designing a plant of this kind, there are numerous other and smaller matters which come up for consideration and which are quite important. In the most of these, however, they are quite easily solved and do not require a great deal of special consider-

ation. To properly deal with the subject of the construction of packing houses there should be included quite a section on the mechanical equipment of these plants, but this would be quite outside the realm of the present topic which must be confined to structural questions. It is hoped that what has been said on this subject will be of interest as showing something of the many special and intricate problems which the building of such a plant as this imposes upon the structural designer and to emphasize the need for men well versed in these particular requirements to layout and supervise work of this kind.